CONVERTER

FIELD OF THE INVENTION

The present invention relates to a converter.

BACKGROUND INFORMATION

5   In the case of converters, is conventional that the actual
value I_actual of the motor current can be measured, the
current-sensing device being situated in the converter. The
signals provided by the current-sensing device of the control
electronics are initially supplied to a filter 1, e.g., a PT1
10 filter, as shown in Figure 1. Therefore, microcontroller 2 is
provided with filtered measuring signals, and interference
signals become suppressible. The PT1 filter may take the form
of a low-pass filter having a time constant of, e.g., 20 μs.

15 In the case of these converters, it may be that when long
cables are used between the converter and the powered electric
motor, and the capacitance of the cable produces recharging-
current peaks that are too high. This is because the
converters are operated in a pulse-width-modulated manner, and
20 a change in voltage at the output of the converter produces
large, short-term, charging-current peaks of this cable
capacitance.

SUMMARY

25 Example embodiments of the present invention may improve the
current sensing in converters.

Features of the converter, include that it at least includes
device(s) for measuring the currents supplied to the electric
30 motor that is powered by the converter, the device(s) for
current sensing being arranged inside the converter, and the
signals of the device(s) being fed to a nonlinear filter,

whose output signals are fed to an additional filter that is connected to an analog-to-digital converter.

It may be provided that a high control performance and control quality are attainable in converters, which are connected, in each instance, to the powered electric motor via long cable, for the recharging-current peaks produced due to the high cable capacitance may be effectively filtered away, e.g., at least one order of magnitude more than in the case of a mere PT1 filter. In this context, it may be provided that not only the peak value of the filtered signal is less, but that above all, the voltage-time area may be provided to be much less than in the case of a PT1 filter or other linear filters as well.

The nonlinear filter is arranged such that the changes in the value of the current, which are motor-dependent, i.e., determined by the arrangement of the electric motor, are transmitted substantially undisturbed. In contrast to this, recharging-current peaks of shorter duration than the characteristic time of the nonlinear filter are suppressed in the measuring signal. However, changes in current that are caused, for example, by mechanical load changes of the rotor of the electric motor are transmitted substantially unchanged.

The analog-to-digital converter may be integrated in a microcontroller or microprocessor. In this context, it may be provided that as few inexpensive components as possible are usable.

The nonlinear filter may be a run-up transmitter. In this context, it may be provided that a component is producible, which is particularly simple to construct.

The run-up transmitter may include a comparator and an integrator. This may provide that standard components may be utilized.

5   The additional filter may be a PT1 filter. This may provide that the circuitry of the related art only requires a few simple modifications.

The value corresponding to the rated current of the converter
10   may be attainable for the run-up transmitter in a time between, e.g., 5 and 10 µs. This may provide that the filtering is highly effective and the voltage-time area is much less than in the case of using a PT1 filter having a corresponding time constant.

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The PT1 filter may have a time constant having a value between, e.g., 15 and 25 µs, e.g., approximately 20 µs. This may provide that conventional components are usable.

LIST OF REFERENCE CHARACTERS

1 filter

2 microcontroller

3 run-up transmitter

31 comparator

32 integrator having a level converter

41 operational amplifier

42 operational amplifier

R1 resistor

R2 resistor

C1 capacitor

C2 capacitor

Example embodiments of the present invention are explained in more detail below with reference to the appended Figures.

BRIEF DESCRIPTION OF THE DRAWINGS

5   Figure 1 illustrates a conventional filter.

Figure 2 illustrates an example embodiment of the present invention.

10   Figure 3 illustrates an example embodiment of the present invention.

Figure 4 is a circuit layout diagram.

15   Figure 5 illustrates a pulse.

Figure 6 illustrates a response of a conventional PT1 filter.

Figure 7 illustrates a response of a run-up transmitter.
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Figure 8 illustrates a response of a filter connected to a run-up transmitter.

BRIEF DESCRIPTION OF THE DRAWINGS
25   Certain features of example embodiments of the present invention are illustrated in Figure 2. A run-up transmitter 3 is connected in outgoing circuit to the current-sensing device. The output signal of the run-up transmitter is subjected to the usual filtering, i.e., fed to low-pass filter
30   1, and the signals filtered in this manner are then fed to the microcontroller.

In an ideal case, the run-up transmitter has the characteristic that its output signal increases at a fixed
35   rate of change, as long as the output voltage is less than the

input voltage. In a similar manner, its output signal decreases at a fixed rate of change, as long as the output voltage is greater than the input voltage. Therefore, when the input signal changes more slowly than what corresponds to

5   these two rates of change, then the output signal is equal to the input signal. Deviations from this ideal behavior may occur in practice.

A basic arrangement of the run-up transmitter is illustrated

10   in Figure 3. In this context, the output of a comparator 31 is fed to an integrator 32, and the output signal of integrator 32 is used by comparator 31. Therefore, as long as there is a difference between the input and output variables of the run-up transmitter illustrated Figure 3, the output of

15   comparator 31 will have a positive or negative value as a function of the algebraic sign of the difference. The output signal of integrator 32 increases linearly with time or decreases linearly with time. All in all, a short-term, rectangular input variable is converted into a small

20   triangular pulse. The slope of the triangular waveform is a function of the time constant of the integrator. In example embodiments of the present invention, this is selected to be greater than the typical duration of the recharging-current peak for the charging of the cable capacitances.

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The maximum slope of the output signal of the run-up transmitter is selected so that its magnitude is greater than the maximum slopes of the motor-current characteristic. These slopes of the motor-current characteristic are substantially

30   determined by the inductance of the electric motor and the applied voltage and the induced voltage in the motor. Therefore, the motor currents are not low-pass filtered, but the current characteristic to be measured is passed through the subsequent circuit elements substantially unchanged.

35   However, the recharging-current peaks are sharply reduced,

because they have a considerably greater slope than the
mentioned, maximum voltage of the output signal of the run-up
transmitter.

5   An example of a circuit layout is illustrated in Figure 4.
However, other circuit layouts may also be used. In Figure 4,
the comparator is implemented with the aid of operational
amplifier 41, as well as the surrounding circuit elements.
Its output signals are fed to integrator 42, R4, R5, R6, R7,
10   and C1 with level conversion, this integrator having a time
constant between, e.g., 2 and 10 µs, and operational amplifier
42 being provided to be used for level conversion. The output
signal is fed back to the input of the comparator via resistor
R8. Capacitor C2 is used to prevent the set-up from
15   oscillating. Further components are also provided and
dimensioned for preventing oscillation, such as C3. The
comparator is implemented as an amplifier having a high gain,
which is determined by R1, R9, R2, and R8.

20   Illustrated in Figure 5 is an example of a pulse, which
schematically illustrates the time characteristic of a
recharging-current peak normalized to 1, the recharging-
current peak having a pulse width of somewhat greater than 1
µs. In the case of shielded cables several meters long, for
25   example 20 m, recharging-current peaks may exhibit peak values
of several ampere, for example 10 ampere and greater. The
real time characteristics are not rectangular pulses as
illustrated in Figure 5, but have a sharply damped oscillatory
characteristic, which is also determined by the inductance of
30   the cable and by other variables. However, the symbolic shape
of the recharging-current peak is used for more effectively
understanding example embodiments of the present invention and
the behavior of the run-up transmitter in comparison with
conventional arrangements. The voltage-time area of the

represented, symbolic recharging-current peak is comparable to recharging-current peaks.

Figure 6 illustrates the response of a conventional PT1 filter
5   having a time constant of 20 μs, to the recharging-current peak illustrated in Figure 5. This corresponds to conventional arrangements. The filtered value reaches a magnitude of 0.08, i.e., 8% of the recharging-current peak. The discharging time of the PT1 filter is very long. The
10 voltage-time area is very large as well.

Figure 7 illustrates the response of the run-up transmitter to the recharging-current peak illustrated in Figure 5. The peak value reaches a magnitude of 0.05, i.e., only 5% of the
15 recharging-current peak. The discharging time of the run-up transmitter is very short and is approximately, e.g., 2 μs. The voltage-time area is very small as well. Deviations from an ideal triangular shape of the response result from the fact that the comparator does not have an infinitely high
20 amplification, but only a finite amplification for suppressing oscillatory behavior.

Operational amplifier 41 may be selected to from saturation into the active control range within less than, e.g., 200 ns.
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Figure 8 illustrates the response, when conventional filter 1 is connected in outgoing circuit to run-up transmitter 3. It is illustrated that the recharging-current peak has only a very small effect on the output signal fed to microcontroller
30 2.

Therefore, example embodiments of the present invention may provide a nonlinear filter, which may suppress recharging-current peaks in a highly effective manner and, consequently,

also may allow a very high control quality in the case of
converters having long cables leading to the powered motor.